Technology and Pharmacy: Theory, Practice, and the Future Vision

Darrin Baines*, **Zaheer-Ud-Din Babar**†, *Bournemouth University, Bournemouth, United Kingdom; †University of Huddersfield, Queensgate, Huddersfield, United Kingdom

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Introduction 211
Pharmacy Practice and Technology 212
Exploration of the Foundational Statements, Technology, and Pharmacy Practice 212
What is Technology? 213
Technology in the History of Pharmacy 213
Renaissance of Community Pharmacies Based Upon Emerging Health Technologies 214
GPTs and TEP 215
The Concept of "Technology-Enabled Pharmacy" 215
Conceptual Framework: Relationship Between Technology and Pharmacy Practice 216
Pharmacy Action Research Cycle 217
Conclusions 218
References 218
Further Reading 219

The purpose of this chapter is to examine the importance of technology to pharmacy practice. We do not discuss this relationship using the everyday, reductionist interpretation of "technology" being manufactured objects (such as laptop computers) or technological processes (such as algorithms). Instead, we emphasize its "performative" nature by focusing on the ways in which human performance can be enhanced technologically. To fully understand this issue, we explore how different philosophies of pharmacy practice (for instance, dispensing and pharmaceutical care) discuss, analyze, and treat technology as an issue. From our exploration, we suggest that the existing philosophies fail to fully represent technology and its wide ranging implications for professional activities. In response, we suggest that there is a need for a supporting conceptual framework to help fill the gaps, which we introduce in summary. We also present a cyclical model of planning, action, and fact-finding based upon the principles of action research that may be used to examine pharmacy-related technologies throughout their lifecycle. Finally, we conclude that pharmacy practice is inseparable from technology and now is the time for the profession to rethink its technological worldview.

To meet the primary aim of this chapter, we perform the following tasks in the sections below. First, we provide an introduction to health technology using the World Health Organization (WHO) definition and discuss its implications for pharmacy. Next, we explain how technology may be viewed as "performative" and introduce the concepts of "intrinsic" and "extrinsic" technologies. In third section, we provide a brief history of the use of technology in pharmacy practice. The fourth section introduces the concepts of General Purpose Technologies (GPTs) and Technology-enabled Pharmacy (TEP). Next, we outline the conceptual framework suggested by Baines and Hale (2005) and discuss the importance of its institutional perspective. The sixth section presents a cyclical model of the technological lifecycle based upon the principles of action research. Finally, we conclude that technology is, and will always be, a vital part of pharmacy practice and it is important that further research and development is performed on this topic.

Introduction

The WHO defines "health technology" as the "application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures, and systems developed to solve a health problem and improve quality of lives." This definition is written from a "performative" perspective because the holders of technical knowledge don't just report what they know as education or narratives, but they must be productive and do it efficiently by maximizing input/output ratios (Lyotard, 1986). Therefore, technologies should be viewed as part of dynamic production processes involving both humans and machines, changing in time, evolving within societal institutions, redefining professional roles, shifting technical and economic boundaries. In other words, health technologies are designed to enhance human performance at improving human health and well-being.

The World Health Assembly (WHA) is the decision-making body of the World Health Organization (WHO). In 2007, the WHA recognized that health technologies are indispensable tools for effective and efficient prevention, diagnosis, treatment, and rehabilitation, as well as the attainment of internationally agreed health-related development goals (WHO, 2007). In its report, the WHA specifies that health technologies are both a technical and an economic challenge to health systems worldwide. The WHA adds that investments in health technologies (particularly medical devices) are inappropriate if they: (1) do not meet

high-priority needs, (2) are incompatible with existing infrastructures, (3) are irrationally or incorrectly used, or (4) do not function efficiently. Used wisely, health technologies have their costs and their benefits. Used inappropriately, they are a potentially damaging waste of resources.

The WHA statement suggests that technologies may be viewed from both a technical and an economic point of view (Freeman, 1994). From the former, the successful adoption of new technologies is an engineering problem, which considers the best means of implementing new technical procedures to deliver specified outcomes. In short, what works best to solve specific problems. From the latter, technology adoption is a question of resource use and redistribution. For instance, do the benefits of novel technologies outweigh their costs? This question is addressed by health economists working within the field of Health Technology Assessment (Dawoud and Baines, 2017). Often, economic evaluation studies find that new technologies that are technically feasible are not economically viable. Therefore, all new technologies funded from cash-limited health-care budgets should not only be effective but should be proven to be cost-effective. In other words, they should also be performative. However, recent evidence on the effectiveness and cost-effectiveness of health technologies used in a pharmacy setting has been relatively poor (Baines et al., 2018b).

Pharmacy Practice and Technology

All pharmacy practice relies on some form of technology or another. Both old and new technologies contribute significantly to the technical operation of pharmacy systems. For instance, computerized ordering systems are often employed to maintain medicines inventories (Awaya et al., 2005). Similarly, pharmaceutical care services frequently use software that records patient details and interventions provided (Rossing et al., 2019). As these examples suggest, most pharmacy practice is "technology-enabled" in the sense that the capabilities and the performance of pharmacy practitioners is enhanced by its use. Sometimes, the technologies utilized are mature and long established (they are "vintage"). Other times, they are novel and previously untried (they are "novel"). In this respect, pharmacy is no different to other professions, industries or retail sectors that rely on old and new technologies to supply goods and services for an identifiable gain.

Given that pharmacy is similar to many other economic sectors in its experience of using technology, should pharmacy technology be a separate topic? We suggest that the answer to this question should be "yes" because three fundamental features combine to make the profession a special case. First, the practice of pharmacy is a "craft" (i.e., performed with human hands). Next, the business of pharmacy is a "trade" (i.e., profits are made from providing goods and services). Finally, the practice and the business of pharmacy are based upon identifiable and replicable "routines" (i.e., fixed working patterns and procedures) not employed elsewhere in health systems (Pavitt, 2002).

Combining these features, we can make three foundational statements about pharmacy and technology. First, pharmacy has a "boundary" in the sense that some technical activities are performed by the profession and others are not. Activities that do not involve pharmacists are usually considered to be outside of current pharmacy practice. For instance, pharmaceuticals supplied by dispensing doctors. Next, the practice of pharmacy is "technology-enabled" in the sense that the routines employed for dispensing, pharmaceutical care, counter sales and other professional activities all involve technology. There are very few working practices that do not involve technology somewhere in their procedures or processes. For instance, face-to-face pharmaceutical consultations are usually supported by Information and Communications Technologies (ICTs) that book appointments, record patient details, claim reimbursement, update medical records, order and cancel drugs (Jawla and Rai, 2018). Finally, the routines that define pharmacy as a separate profession must, to be successful, generate resources and reimbursement from health systems commissioners and payers or patients and members of the public. As an example, pharmacists worldwide could support medication switches to newly emerging smart inhaler technologies (Mohammadi, 2018). As yet, there are no examples of health systems or patients paying pharmacists for this type of input. As this example suggests, technological advance not only depends upon invention and innovation but also on appropriate and timely resourcing for the pharmacy profession.

Exploration of the Foundational Statements, Technology, and Pharmacy Practice

An exploration of the foundational statements outlined above may help illuminate the nature of the relationship between technology and pharmacy practice in three ways. First, changes in technology (such as the adoption of novel technologies and the retirement of vintage technologies) will shift the boundaries of pharmacy practice. For instance, advances in robotics could eventually remove, or radically diminish, pharmacist involvement in the dispensing process (Barrett et al., 2012). Consequently, the boundaries of pharmacy practice may shift inwards like they did when industrial drug manufacturing killed compounding as a professional routine (Baines, 2014). Next, changes in technology will also alter what pharmacists do as a profession. For instance, the Internet of Things (IoT) could revolutionize medicines adherence, creating demand for a new specialism, "medicines adherence pharmacy"(Alex et al., 2016). As a result, new methods, technologies, and procedures could combine to create new working routines within pharmacy's shifting boundaries (Strickland-Hodge et al., 2018). Finally, what is technically feasible may not be affordable. As an example, smaller pharmacies serving deprived areas may be unable to afford large-scale robotic dispensaries. Therefore, pharmacy is likely to evolve in a "second best" technological world where funding arrangements and routines mismatch new technical opportunities and the shifting boundary of the profession. Given this situation, a concern with pharmacy technology should, therefore, be a concern with finding the optimal funding and organizational arrangements for

pharmacy practice. However, policies related to pharmacy profession and practice often lag behind the opportunities available to the profession (Kay and Baines, 2017).

What is Technology?

The term "technology" is commonly used to refer to manufactured objects (such as mobile phones) or technological procedures (such as Artificial Intelligence) used by human beings either for their own personal ends or for the production of goods and services for sale (Feenberg, 1991; Vyas et al., 2018). However, this definition reduces the meaning of the concept to the objects and the procedures themselves, while excluding the wider dynamic surrounding their application. For instance, a novel phone app designed to remind patients to take their medicines may be described as a new technology (Car et al., 2017). In practice, the successful use of this innovation by patients may require pharmacist input into associated working processes (such as setting up, regular communications, reviewing, safety checking, and the like). In its truest sense, technology is not just manufactured objects and technological procedures, but also incorporates human inputs and clearly defined operational processes.

An exploration of the etymology of the term "technology" is helpful in clarifying how the word should be applied in a pharmacy context. Technology derives from the Greek word "techne," which means "art, skill, cunning of hand," but also has the implication of "craftpersonship, craft or art." This definition implies that technology is employed by practitioners who develop niche skills in applying specific working practices (Puech, 2016). For instance, pharmacists are experts in the processes surrounding the use of pharmaceutical objects and procedures. Over time, the acquisition and application of practical competencies and technical knowledge creates identifiable groups of practitioners who organize into "crafts" (i.e., occupations or trades requiring skill with the hands). For instance, the widespread consumption of pharmaceuticals by millions of patients worldwide is handled by the profession (craft) of pharmacy, with its specially educated and trained workforce of medicines technologists commonly referred to as "pharmacists." Using this line of reasoning, it is clearly the case that the practice of pharmacy is a craft-based skill, and the profession is defined by the technologies it employs.

As the history of pharmacy demonstrates, technology is not just manufactured objects or technological procedures, but encompasses the dynamics of human performance within identifiable working processes. Following this logic, Baines et al. (2018a) defines "technology' as the "dynamic clustering of techniques, methods, skills, and processes used in the production of goods or services or in the achievement of outcomes that deliver desired benefits for consumers." This dynamic clustering suggests that the relationship between human behavior and technology is "performative," which implies that the human use of technologies evolves over time and is not fixed, *a priori*, but is ceaselessly shaped in social performances that are not routine or matter of fact. Applying this logic, pharmacists may be seen as working within an evolving dynamic of operational methods that shapes the nature of their professional performance. If technological practices alter, the performance of pharmacy practice changes. As our third fundamental feature suggests, the practice and the business of pharmacy are based upon identifiable and replicable "routines" that will evolve as technology changes. For this reason, understanding the nature of technology is a vital prerequisite to generating insights into the possibilities and opportunities that technological advances can offer the profession.

To help understand how technology could create new possibilities and opportunities for pharmacy practice, the following two concepts are useful:

1. "Intrinsic technologies" are innovations that improve current production processes, without changing the range of outputs produced.
2. "Extrinsic technologies" are innovations that expand the range of outputs that are producible, but do not necessarily improve the efficiency of existing or new production processes.

Throughout their history, pharmacists have adopted both intrinsic and extrinsic technologies. As an example of the former, barcode technologies are designed to improve the productivity of dispensing, which improves performance without changing what most pharmacies do. In relation to the latter, recent technological advances could make medical screening possible in a pharmacy setting, thus expanding the range of services available to patients (Lowres et al., 2015). As these examples suggest, technological advances can enable pharmacists to do what they currently do better, as well as creating new production opportunities for the profession. In the hands of pharmacists, new technologies can be performative, both enhancing efficiencies and shifting professional boundaries.

Technology in the History of Pharmacy

Throughout their recent history, pharmacists have undertaken three key roles: compounders, dispensers, and (in the last two decades) providers of pharmaceutical care services. Within the emergence of the modern pharmaceutical industry, pharmacists lost their role as the compounders and the preparers of medicines. In the post-war era, dispensing became the main activity for the majority of pharmacists, with "counter-sales" being a supplementary task in community pharmacy (Baines, 2014). With the

publication of Hepler and Strand (1990), pharmaceutical care became a new vision for professional practice, which shifted the emphasis of pharmacy practice away from dispensing toward the provision of patient services.

During their early history, the evolutionary predecessors of modern-day pharmacists (apothecaries, then chemists and druggists) were "technologists" in the sense of "being experts in a particular field of technology." From the medieval era onwards, apothecaries were specialists in using transformative techniques for turning herbal and other ingredients into potions, poisons and medicaments (Anderson, 2018). This expertise was based upon the technique of "compounding," which involves combining or processing appropriate ingredients using specific tools or processes to meet the personal needs of patients or customers (Anderson, 2005). Through this method of combining, the earliest makers of medicines were able to produce a wide range of diverse products. Vela Aulesa (2015, p. 132) discusses their working practices:

> What linked the diversity of their products that, in many cases, the apothecaries themselves made in their workshops? The answer is that they all shared the same production techniques: decoction, infusion, distillation, sublimation, maceration, pulverization, dissolution and conservation in sugar or honey. The apparent diversity of uses concealed great technical uniformity: most compounds were obtained from formulae that involved similar techniques to obtain products made in exactly the same way but varied in their uses.

The quote suggests that apothecaries were directly involved in the manufacturing process, shaping the products with their own hands. Also, the class of practitioners referred to as apothecaries were definable as a group because they shared the same production techniques (Hunting, 1998). Finally, a diversity of products was achieved using highly uniform technical processes or techniques, which we refer to as "routines."

During the 19th century, chemists and druggists in countries such as the United Kingdom, America, and Germany were at the forefront in experimenting with innovations in the emerging field of modern chemistry (Marland, 1987). Their work not only created new medicines but also led to major developments in manufacturing processes outside pharmacy (such as new methods in the production of dyes). In other words, chemists and druggists developed intrinsic as well as extrinsic technologies. These practitioners also responded with fervour to the opportunities offered by the introduction of mass-produced glass (Silverman, 1953). For instance, they filled their shops with mirrors, glass-fronted cabinets, bottles, and carboys, as well as investing in expensive plate-glass windows to attract customers inside (Chemist and Druggist, 1915).

During this time, chemists often had a workshop at the rear of their retail premises, but would also compound or mix preparations in front of customers. In the medicines marketplace, more successful producers would sell their concoctions to other retailers and an industry of branded medicines flourished until the introduction of institutional controls on the sales of such goods. This trade was enabled by the development of railway networks connecting important commercial centers. To further serve their trade, chemists and druggists led the way in innovating new means of formulating final products, including inventing machines for making tablets, creating capsules, and packaging powders. During the early-20th century, they were among the first retailers to experiment with moving shop displays that used electric motors to create moving parts to attract the attention of passers-by.

As the involvement of the profession in chemistry diminished, during the 20th century pharmacists positioned themselves at the forefront of the revolution in mass-produced medicines by stocking their shops with a rapidly growing range of branded drugs. Accompanying this revolution was a rejection of glass as the defining feature of the pharmacy premises. Instead, technological advances in paper and plastics led to boxes and blister-packs becoming the key methods of medicines storage and display. Pharmacists evolved by responding rapidly to the opportunities offered by new waves of pharmaceutical and retail technologies. Today, this process can be seen again with the increasing adoption of robotic and barcodes dispensing, as well as digital Dossett boxes and pill dispensers (Furmedge et al., 2018).

Throughout history, the dual focus on technological advancement and successful retailing has been a defining feature of the pharmacy profession (Scott and Walker, 2018). The rapid introduction of a new wave of digital technologies in coming years will again make apparent the importance of the technology–retailer relationship in pharmacy practice. Innovations such as robotic dispensing, adherence monitoring devices, the Internet of things, and the like will revolutionize dispensing and pharmaceutical care (Baines et al., 2018b). Emerging technologies will create novel opportunities for the profession, which may be a catalyst for a renaissance in pharmacy practice and a redefinition of the primary purpose of community pharmacy premises.

Renaissance of Community Pharmacies Based Upon Emerging Health Technologies

As pharmaceutical care focuses on the development of professional knowledge and skills for individual pharmacists, since 2000 pharmacy premises have largely been ignored as an area of professional concern. In response, Baines (2015a) proposes a renaissance of community pharmacies based upon emerging health technologies. He argues that community pharmacies should become the health-care technology hubs of the future. To make his vision of Technology Enabled Pharmacy a reality, Baines suggests five steps:

1. Refit the "front of house" as a technology hub that allows patients to connect with the pharmacy, local doctors, the health-care system, pharmaceutical companies, charities, other patients and the like;
2. Exploit the time that patients wait for their prescriptions by connecting them to a technology-enabled task, such as reporting on their medicines use, watching an interactive educational program, completing a questionnaire, or being expert patients in research studies;

3. Network the pharmacy hub into the wider health-care community, including providers, patient groups, and private companies (by doing so become the port of first call for patients), and coordinate their care through the pharmacy's technology-enabled network;
4. Retrain pharmacists in health-care technology not just medicines optimization;
5. Educate and enable the public to become technology-enabled pharmacy users.

These steps are important because they suggest that (1) pharmacies could become the focus of technology enablement not just pharmacists, (2) extrinsic technologies may be important to the future development of the profession, and (3) dispensing may become a poorly reimbursed task completed solely to attract footfall so that other technology-enabled services may be provided. As these developments suggest, the opportunities and threats created by the digital age may encourage the pharmacy profession to evolve yet again.

GPTs and TEP

With the ongoing advance of digital, it is vital that pharmacists fully understand the nature of innovative technologies and their potential impact on the profession (Karampatakis et al., 2018). Following the lead of economists and other social analysts, pharmacists could classify technologies into two basic classes. On the one hand, "general purpose technologies" (GPTs) are those that affect an entire economy and have the potential to disrupt the economic life of whole societies (Helpman, 1998). Lipsey et al. (2005) report that there have only been 24 GPTs in history, including the steam engine, trains, electricity, computing, the Internet, artificial intelligent, and block chain. In contrast, "enabling technologies" are innovations that are directly designed to improve the capabilities or the performance of specific users not society as a whole. For instance, telehealth technologies are designed to enable long-distance communications between health practitioners and patients. Such advances can revolutionize care provision, particularly in rural areas, but will not have spill over effects elsewhere.

Normally, GPTs will eventually affect all industries in an economy. For instance, it is hard to imagine any industrial sector not using electricity or information technology (IT), which are considered to be the two most important GPTs (Jovanovic and Rousseau, 2005). In a pharmacy context, this implies that professional working practices will eventually be affected by all new GPTs (for instance, block chain). As major innovations sweep through the economy, the question is not whether novel technologies should be adopted, but when and how diffusion will occur? (Rogers, 2010). In response to emerging GPTs, there is an argument for profession-wide action because the widespread adoption of whole economy technologies may achieve better outcomes if all production units are involved. For instance, most pharmacy bodies support the use of the Internet as a means of individual pharmacies or chains communicating with patients. For example, via social media (Benetoli et al., 2015). The regular use of such technologies ensures that the profession does not lag behind technical developments commonly adopted in other industries. In sum, GPTs can be seen as a special case, especially due to their rare occurrence and disruptive effects.

The Concept of "Technology-Enabled Pharmacy"

Baines (2015a) coined the term "technology-enabled pharmacy" (TEP) to describe the use of intrinsic and extrinsic technologies within a pharmacy setting. The concept of TEP is based upon the notion that technology can improve the capabilities of pharmacists to deliver patient services. As a concept, it is based upon "extension theory," which Lawson (2010) reports conceives of technical objects as "some kind of extension of the human organism by way of replicating, amplifying, or supplementing bodily or mental faculties or capabilities." For instance, enabling technologies could enhance the physical and the mental capacities of working pharmacists, which could increase their incomes and benefit patients. Linking this implication to the notion of intrinsic and extrinsic technologies, TEP has the power to innovate current production processes and to expand the range of outputs pharmacists currently produce.

The above discussion suggests that the impact of GPTs and TEP may be either evolutionary or revolutionary. This may be illustrated using Fig. 1, which shows the relationship between production outputs and costs. Within economics, the operational dynamics that transform the physical inputs of capital, labor, and consumables (i.e., the costs of production) into planned outputs are called "production functions." Production functions for dispensing and pharmaceutical care are outlined by Baines et al. (2018a). Production processes consume inputs in the forms of: (1) labor from pharmacists, technicians, and auxiliary staff; (2) capital investment in premises and production technologies such as automated dispensing; and (3) consumables in the forms of the items used during supply (such as medicines packaging) and pharmaceutical care consultations (such as computing support).

In Fig. 1, the vertical axis shows the outputs derived from pharmacy practice activities such as dispensing and pharmaceutical care. On the horizontal axis, the costs of production are shown. As the model assumes diminishing returns, the relationship between costs and outputs is shown by the curved lines that represent various production functions (PFs). Each PF represents a different package of technology and maps a different relationship between costs and outputs. As the Fig. 1 shows, PF2 is an incremental improvement over PF1. For instance, a new software package for stock control may yield only marginal improvements in dispensing efficiency. In contrast, PF3 is a "technology shock" and represents a major improvement in the outputs that can be produced with existing resources. For instance, pharmaceutical care technologies (such as "smart pill" systems) may greatly enhance productivity. In

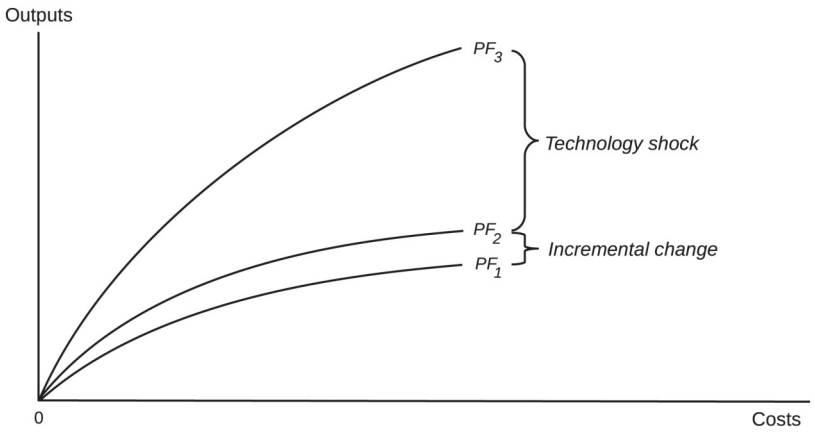

Figure 1 Technology shock verses incremental change.

sum, improvements in productivity are often variable. To secure improvements in performance, pharmacists should pursue small gains that accumulate slowly over time, as well as sudden technology shocks.

Conceptual Framework: Relationship Between Technology and Pharmacy Practice

How the relationship between technology and pharmacy practice is analyzed will often depend upon the conceptual framework adopted. Conceptual frameworks allow researchers to organize ideas about empirical topics. For instance, how should we categorize what we currently know about the monitoring technologies useable in a pharmacy setting? There are several prominent philosophies for analyzing pharmacy practice, notably those for dispensing and pharmaceutical care. Despite their widespread employment, both have limitations in the current context. For instance, the practice philosophy for dispensing focuses primarily on drug supply, while pharmaceutical care was developed in 2000 before the emergence of many new technologies such as the Internet, mobile devices, block chain, and many others. Therefore, pharmacy needs a robust conceptual framework that can truly organize the profession's thinking and knowledge about the ways that technology can and will affect its working practices.

Baines and Hale (2005) outlines a conceptual framework for analyzing how environment, institutions, organizations, and philosophy all influence the ways that pharmacy services are provided. At its core, the framework is based upon a paradigm of thinking developed within economics referred to as "new institutionalism." This approach claims that "history matters" in the sense that current economic opportunities are shaped by the evolutionary paths that economic entities follow. Borrowing a quote from Greif (1998, p.82), the institutional approach suggests that today's pharmacy practice is a product of an "historical process in which past institutional, economic, political, social, and cultural features interact in shaping the nature of contemporary institutions and their evolution." For instance, pharmacists in the United Kingdom became dispensers of medicines (rather than general practitioners) due to a series of unintended events and historical accidents. Because history matters, today's professional arrangements are not based solely upon logical design (Baines, 2015b).

The model in **Fig. 2** represents the conceptual framework suggested by Baines and Hale (2005). Starting at the bottom of the pyramid, environmental factors (such as public funding for pharmacy services and general economic conditions) are the first influence on pharmacy practice. For instance, if governments support technologies that enable pharmacists working in nursing homes, then new roles may be created for the profession. Next, the diagram suggests that pharmacy is governed by a range of "institutions," including laws, regulations, rules, conventions, ethics, and norms governing behavior (Baines and Hale, 2005). Institutions like these limit the innovations deemed suitable for professional use. For instance, the Food & Drug Administration (FDA) regulates the use of novel health technologies, including medicines (Molteni, 2017). Its rules are the

Figure 2 Hierarchy of influences on pharmacy practice.

main institution governing the adoption of digital technologies by pharmacists and other health-care professionals in the United States.

Institutions are important because, as Douglas North (1991) states, they are "the humanly devised constraints that shape human interaction" or, put differently, "the rules of the game in a society." In other words, they are social limits imposed upon technology-enabled individuals. Above institutions in the hierarchy are organizations, which North (1991) defines as "groups of individuals bound by some common purpose to achieve objectives." In order to realize their aims, organizations of individuals must become players of the institutional games governing their activities. For instance, independent and multiple pharmacies may be seen as separate groups of players organized to work for the objective of generating revenue by dispensing drugs within the institutions governing medicines supply. Like most games, technology may be employed to enable players to compete more effectively. For instance, pharmacies could offer coordinated home deliveries using app technologies, which will help them generate more revenue by reaching customers over wider areas than other local pharmacy shops. As rules can be broken, professional and other bodies often police the behavior of players in institutional games. For instance, data protection legislation in many countries imposes penalties on pharmacists who break the rules governing the use of confidential patient information (Gostin et al., 2018).

Although most companies strive to be competitive, they also place limits upon themselves by adopting philosophies that guide their tactics for survival. For instance, most companies now have environmental policies that stop them pursuing profits at any cost. During the 20th century, many pharmacists in the United Kingdom adopted the philosophy of education, professionalism, and fraternity originated by the founder of the Pharmaceutical Society, Jacob Bell. As a result, pharmacy was viewed as a profession not just a trade, which motivated how many pharmacists played the pharmacy game (Holloway, 1991). As time passed, Jacob Bell's practice model evolved, but became less important after the philosophy of pharmaceutical care was launched by Hepler and Strand in 2000. With this change in dominant philosophy came a shift away from dispensing toward patient services as the major concern of pharmacy practice philosophers. In Scotland, this shift led to the emergence of government policy promoting robotic dispensing as a means of freeing community pharmacist time to work with patients (van der Meer et al., 2015). As this example suggests, philosophy of practice is one among a number of key influences that affects pharmacy and its use of technology.

Finally, in the hierarchy, is the practice of pharmacy. This is not the philosophy of practice, but the actions and behaviors of pharmacy practitioners. Because pharmacy is a craft, pharmacists learn by doing, as well as through education and training. In other words, pharmacy practice is a form of "action research." The founder of the approach, Kurt Lewin, describes action research as "comparative research on the conditions and effects of various forms of social action and research leading to social action." In his original paper, he wrote that the method of inquiry follows a "spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action" (Lewin, 1946). Torbert and William (1981) adds:

> Knowledge is always gained through action and for action. From this starting point, to question the validity of social knowledge is to question, not how to develop a reflective science about action, but how to develop genuinely well-informed action – how to conduct an action science.

As this quote suggests, understanding gained directly from experience may equal or surpass the importance of knowledge learnt from academic education and training. For instance, what practitioners learn from implementing telehealth technologies may be more important than knowledge they can read or be taught (Hebert et al., 2006). In response to this insight, pharmacy practitioners should be guided by a circle of planning, action and fact-finding that illuminates the process of technology adoption, use and decommissioning in their working practices.

Pharmacy Action Research Cycle

As the process of adopting, using, and rejecting specific technologies is dynamic, the pharmacy profession requires a cyclical approach to technological planning, action, and fact-finding. Fig. 3 meets this need by presenting an action research cycle for pharmacy, which embodies the following seven tasks:

1. Scope—The process of technology adoption (or modification) begins with the task of looking for technological advances that could improve or expand production opportunities.
2. Formulate—Next, identified possibilities are expressed as operational blueprints or formulae that include details of how novel technologies may be incorporated into existing (and possibly new) production processes.
3. Experiment—The third task is to test new technological processes under experimental conditions as a means of exploring their performance and safety before widespread dissemination.
4. Reify—Innovations that prove to be promising in controlled experiments may be developed into an actual, concrete procedures useable in practice. These technological processes should have definite forms and functions and be part of identifiable production processes.
5. Implement—Next, reified technological processes are introduced into existing, or innovated, production processes. The ways in which existing production processes are performed may be temporarily modified until new technologies are fully embedded.

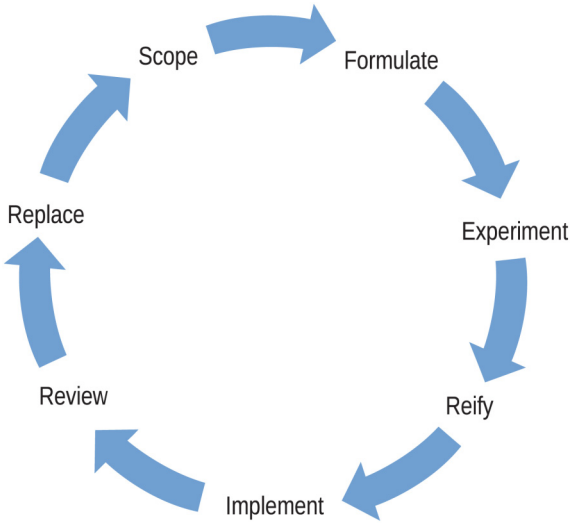

Figure 3 Pharmacy action research cycle.

6. Review—Introduced technologies should be critically evaluated at key stages in their implementation and use. At the beginning, the green light may be given for widespread adoption. At maturity, evidence may suggest that an incumbent technology should be retired.
7. Replace—Finally, technologies that may be replaced with more efficient or superior procedures should be removed from production. However, the need for large-scale capital investment may delay the replacement of some suboptimal technologies.

Together, the above tasks suggest the following: (1) technologies are performative processes that experience complex lifecycles, (2) one-off evaluations like HTA will not capture their true nature, and (3) the use of novel and vintage technologies can be optimized using an action research approach to supporting practitioner learning, evaluation, and choice.

Conclusions

Throughout their history, pharmacists have always been technologists. Their work has led to the development of an untold number of innovations that have benefited the trade of pharmacy and the lives of patients. As well as being inventors, pharmacists have adopted innumerable GPT and TEP technologies developed elsewhere for both general and pharmacy use. With the evolution of the digital age, a new wave of innovations is emerging at a time when the profession is looking for new roles and health systems are seeking to better manage costs. In response, we presented a performative perspective on pharmacy practice and highlighted the importance of taking an institutional approach to analyzing the development of pharmacy-related technologies. After discussing the pertinent issues, we suggested that pharmacists should take an action research approach to understanding the lifecycle of the technologies harnessed by the profession. In sum, we conclude that pharmacy practice is inseparable from technology and now is the time for the profession to rethink its technological worldview.

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